Invited LEOS'98 - TuN1 Orlando. 1-4 Dec 1729

Diode-bar-pumped planar waveguide lasers

A. C. Tropper, C. L. Bonner, C.T.A. Brown, D. P. Shepherd,

W.A. Clarkson and D. C. Hanna

Optoelectronics Research Centre

Department of Physics and Astronomy

University of Southampton

Southampton SO 17 1BJ

U.K.

Tel: +44 1703 592103   FAX: +44 1703 593142

email act@orc.soton.ac.uk

Abstract

Diode-bar-pumped planar waveguide lasers can be powerful and compact laser sources. We report a Nd:YAG-based device which emits 6.2W at 1064 nm with an overall optical-to-optical conversion efficiency of 31%.

Diode-bar-pumped planar waveguide lasers

A. C. Tropper, C. L. Bonner, C.T.A. Brown, D. P. Shepherd, W.A. Clarkson and D. C. Hanna

Optoelectronics Research Centre

Department of Physics and Astronomy

University of Southampton

Southampton SO 17 1BJ

U.K.

Tel: +44 1703 592103 FAX: +44 1703 593142
email act@orc.soton.ac.uk

Summary

Diode-bar lasers have been used with great success to pump high power solid state lasers in numerous different geometries; nevertheless it remains a challenge to use the highly asymmetric diode-bar output efficiently. We describe an approach to this problem in which the solid-state gain medium is fabricated as a planar waveguide, into which the high-aspect-ratio emission from the diode-bar can be coupled using a simple optical system[1]. This is a geometry which should in principle handle heat dissipation well; a thin slab has a higher stress fracture limit than, for example, a rod, and the 1-dimensional heat flow provides a benign birefringence behaviour. Moreover the optical confinement of the pump light enhances the gain per unit pump power, allowing low-gain transitions to be operated efficiently.

We have investigated the performance of a planar Nd-doped $Y_3Al_5O_{12}$ waveguide pumped by a 20-W 807-nm diode-bar (Opto Power Corporation). A high-quality, low propagation loss guide is essential for such a device; in this experiment we used a liquid-phase-epitaxy-grown structure provided by B. Ferrand of LETI (CEA-Technologies Avanceés) at the Centre D'Etudes Nucléaires de Grenoble. The 5-mm long waveguide had an 80-μm-thick 1.5-at.% Nd:YAG core sandwiched between substrate and protective cladding layer of undoped YAG. The Nd content of the core raised its refractive index by 4.8×10^{-4} relative to substrate and cladding, creating an optical waveguide with a numerical aperture of 0.06.

Pump radiation from the diode-bar was coupled into the waveguide using a cylindrical lens system which produced a line focus at the input face of the waveguide with measured beam radii of 10μm and ~1 mm along the guided and non-guided axes respectively. A monolithic laser cavity was formed by dielectric coatings applied to the plane-parallel end-faces of the waveguide, with nominal 1064-nm reflectivities of ~100% and 95% at the input and output ends respectively. A schematic diagram of the experimental arrangement is shown in Fig. 1a).

Fig. 1. a) Schematic arrangement of waveguide laser. The cylindrical lens system is composed of lenses with focal lengths A = -6.35mm, B = 12.7 mm, C = 19 mm, and D = 6.35 mm.
b) Output power of the waveguide laser as a function of diode-bar current

a)

b)

The output power from this waveguide laser is shown as a function of diode-bar current in Fig.2. At the maximum operating current of 29 A the diode-bar emitted 20 W, and 31% of this power was converted into waveguide laser output. The output beam from the waveguide laser had M^2 values measured to be 3 and 140 in the guided and unguided directions respectively, compared with values of 1.6 and ~2000 for the beam emitted by the diode-bar.

A number of improvements on this device can be envisaged, including the use of a thinner waveguide, better control of the lasing mode in the unguided direction using an external resonator, and the application of a metal overlayer to an unclad guide to give polarized output[2]. The recent demonstration of high quality lasing waveguides fabricated by thermal bonding[3] suggests the possibility of even simpler schemes to couple diode-bar output into guides of high numerical aperture.

1. C. L. Bonner, C. T. A. Brown, D. P. Shepherd, W. A. Clarkson, A. C. Tropper, D. C. Hanna and B. Ferrand, Opt. Lett. 23, (1998) 942 - 4

2. C. T. A. Brown, R. D. Harris, D. P. Shepherd, A. C. Tropper, J. S. Wilkinson and B. Ferrand, to appear in Photonics Technology Letters

3. C. T. A. Brown, C. L. Bonner, T. J. Warburton, D. P. Shepherd, A. C. Tropper, D. C. Hanna and H. E. Meissner, Appl. Phys. Lett. 71, (1997) 1139 - 1141